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- Into the Comet
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Into the Comet
by Arthur C. Clarke

I don't know why I'm recording this," said George Takeo Pickett slowly into the hovering microphone. "There's no chance that anyone will ever hear it. They say the comet will bring us back to the neighbourhood of Earth in about two million years, when it makes its next turn around the sun. I wonder if mankind will still be in existence then, and whether the comet will put on as good a display for our descendants as it did for us? Maybe they'll launch an expedition, just as we have done, to see what they can find. And they'll find us…

"For the ship will still be in perfect condition, even after all those ages. There'll be fuel in the tanks, maybe even plenty of air, for our food will give out first, and we'll starve before we suffocate. But I guess we won't wait for that; it will be quicker to open the air lock and get it all over.

"When I was a kid, I read a book on polar exploration called *Winter Amid the Ice*. Well, that's what we're facing now. There's ice all around us, floating in great porous bergs. *Challenger's* in the middle of a cluster, orbiting round one another so slowly that you have to wait several minutes before you're certain they've moved. But no expedition to Earth's poles ever faced our winter. During most of that two million years, the temperature will be four hundred and fifty below zero. "We'll be so far away from the sun that it'll give about as much heat as the stars. And who ever tried to warm his hands by Sirius on a cold winter night?"

That absurd image, coming suddenly into his mind, broke him up completely. He could not speak because of memories of moonlight upon snowfields, of Christmas chimes ringing across a land already fifty million miles away. Suddenly he was weeping like a child, his self-control dissolved by the remembrance of all the familiar, disregarded beauties of the Earth he had forever lost.

And everything had begun so well, in such a blaze of excitement and adventure. He could recall (was it only six months ago?) the very first time he had gone out to look for the comet, soon after eighteen-year-old Jimmy Randall had found it in his home-made telescope and sent his famous telegram to Mount Stromlo Observatory. In those early days, it had been only a faint polliwog of mist, moving slowly through the constellation of Eridanus, just south of the Equator. It was still far beyond Mars, sweeping sunward along its immensely elongated orbit. When it had last shone in the skies of Earth, there were no men to see it, and there might be none when it appeared

again. The human race was seeing Randall's comet for the first and perhaps the only time.

As it approached the sun, it grew, blasting out plumes and jets, the smallest of which was larger than a hundred Earths. Like a great pennant streaming down some cosmic breeze, the comet's tail was already forty million miles long when it raced past the orbit of Mars. It was then that the astronomers realized that this might be the most spectacular sight ever to appear in the heavens; the display put on by Halley's comet, back in 1986, would be nothing in comparison. And it was then that the administrators of the International Astrophysical Decade decided to send the research ship *Challenger* chasing after it, if she could be fitted out in time; for here was a chance that might not come again in a thousand years.

For weeks on end, in the hours before dawn, the comet sprawled across the sky like a second but far brighter Milky Way. As it approached the sun, and felt again the fires it had not known since the mammoths shook the Earth, it became steadily more active. Gouts of luminous gas erupted from its core, forming great fans which turned like slowly swinging searchlights across the stars. The tail, now a hundred million miles long, divided into intricate bands and streamers which changed their patterns completely in the course of a single night. Always they pointed away from the sun, as if driven starwards by a great wind blowing forever outwards from the heart of the solar system.

When the *Challenger* assignment had been given to him, George Pickett could hardly believe his luck. Nothing like this had happened to any reporter since William Laurence and the atom bomb. The facts that he had a science degree, was unmarried, in good health, weighed less than one hundred and twenty pounds, and had no appendix undoubtedly helped. But there must have been many others equally qualified; well, their envy would soon turn to relief.

Because the skimpy payload of *Challenger* could not accommodate a mere reporter, Pickett had had to double up in his spare time as executive officer. This meant, in practice, that he had to write up the log, act as captain's secretary, keep track of stores, and balance the accounts. It was very fortunate, he often thought, that one needed only three hours, sleep in every twenty-four, in the weightless world of space.

Keeping his two duties separate had required a great deal of tact. When he was not writing in his closet-sized office, or checking the thousands of items stacked away in stores, he would go on the prowl with his recorder. He had been careful, at one time or another, to interview every one of the twenty scientists and engineers who manned *Challenger*. Not all the recordings had been radioed back to

Earth; some had been too technical, some too inarticulate, and others too much the reverse. But at least he had played no favourites and, as far as he knew, had trodden on no toes. Not that it mattered now.

He wondered how Dr Martens was taking it; the astronomer had been one of his most difficult subjects, yet the one who could give most information. On a sudden impulse, Pickett located the earliest of the Martens tapes, and inserted it in the recorder. He knew that he was trying to escape from the present by retreating into the past, but the only effect of that self-knowledge was to make him hope the experiment would succeed.

He still had vivid memories of that first interview, for the weightless microphone, wavering only slightly in the draught of air from the ventilators, had almost hypnotized him into incoherence. Yet no one would have guessed: his voice had its normal, professional smoothness.

They had been twenty million miles behind the comet, but swiftly overtaking it, when he had trapped Martens in the observatory and thrown that opening question at him.

"Dr Martens," he began, "just what is Randall's comet made of?"

"Quite a mixture," the astronomer had answered, "and it's changing all the time as we move away from the sun. But the tail's mostly ammonia, methane, carbon dioxide, water vapour, cyanogen —"

"Cyanogen? Isn't that a poison gas? What would happen if the Earth ran into it?"

"Not a thing. Though it looks so spectacular, by our normal standards a comet's tail is a pretty good vacuum. A volume as big as Earth contains about as much gas as a matchbox full of air."

"And yet this thin stuff puts on such a wonderful display!"

"So does the equally thin gas in an electric sign, and for the same reason. A comet's tail glows because the sun bombards it with electrically charged particles. It's a cosmic sky-sign; one day, I'm afraid, the advertising people will wake up to this, and find a way of writing slogans across the solar system."

"That's a depressing thought—though I suppose someone will claim it's a triumph of applied science. But let's leave the tail; how soon will we get into the heart of the comet—the nucleus, I believe you call it?"

"Since a stern chase always takes a long time, it will be another two weeks before we enter the nucleus. We'll be ploughing deeper and deeper into the tail, taking a cross section through the comet as we catch up with it. But though the nucleus is still twenty million miles ahead, we've already learned a good deal about it. For one thing, it's extremely small—less than fifty miles across. And even that's not

solid, but probably consists of thousands of smaller bodies, all milling round in a cloud."

"Will we be able to go into the nucleus?"

"We'll know when we get there. Maybe we'll play safe and study it through telescopes from a few thousand miles away. But personally, I'll be disappointed unless we go right inside. Won't you?"

Pickett switched off the recorder. Yes, Martens had been right. He would have been disappointed, especially since there had seemed no possible source of danger. Nor was there, as far as the comet was concerned. The danger had come from within.

They had sailed through one after another of the huge but unimaginably tenuous curtains of gas that Randall's comet was still ejecting as it raced away from the sun. Yet even now, though they were approaching the densest regions of the nucleus, they were for all practical purposes in a perfect vacuum. The luminous fog that stretched around *Challenger* for so many millions of miles scarcely dimmed the stars; but directly ahead, where lay the comet's core, was a brilliant patch of hazy light, luring them onwards like a will-o'-the-wisp.

The electrical disturbances now taking place around them with ever-increasing violence had almost completely cut their link with Earth. The ship's main radio transmitter could just get a signal through, but for the last few days they had been reduced to sending "O.K." messages in Morse. When they broke away from the comet and headed for home, normal communication would be resumed; but now they were almost as isolated as explorers had been in the days before radio. It was inconvenient, but that was all. Indeed, Pickett rather welcomed this state of affairs; it gave him more time to get on with his clerical duties. Though *Challenger* was sailing into the heart of a comet, on a course that no captain could have dreamed of before the twentieth century, someone still had to check the provisions and count the stores.

Very slowly and cautiously, her radar probing the whole sphere of space around her, *Challenger* crept into the nucleus of the comet. And there she came to rest—amid the ice.

Back in the nineteen-forties, Fred Whipple, of Harvard, had guessed the truth, but it was hard to believe it even when the evidence was before one's eyes. The comet's relatively tiny core was a loose cluster of icebergs, drifting and turning round one another as they moved along their orbit. But unlike the bergs that floated in polar seas, they were not a dazzling white, nor were they made of water. They were a dirty grey, and very porous, like partly thawed snow. And they were riddled with pockets of methane and frozen ammonia, which erupted from time to time in gigantic gas jets as they absorbed

the heat of the sun. It was a wonderful display, but Pickett had had little time to admire it. Now he had far too much.

He had been doing his routine check of the ship's stores when he came face to face with disaster—though it was some time before he realized it. For the supply situation had been perfectly satisfactory; they had ample stocks for the return to Earth. He had checked that with his own eyes, and now had merely to confirm the balances recorded in the pinhead-sized section of the ship's electronic memory which stored all the accounts.

When the first crazy figures flashed on the screen, Pickett assumed that he had pressed the wrong key. He cleared the totals, and fed the information into the computer once more.

Sixty cases of pressed meat to start with; 17 consumed so far; quantity left: 99999943.

He tried again, and again, with no better result. Then, feeling annoyed but not particularly alarmed, he went in search of Dr Martens.

He found the astronomer in the Torture Chamber—the tiny gym, squeezed between the technical stores and the bulkhead of the main propellant tank. Each member of the crew had to exercise here for an hour a day, lest his muscles waste away in this gravityless environment. Martens was wrestling with a set of powerful springs, an expression of grim determination on his face. It became much grimmer when Pickett gave his report.

A few tests on the main input board quickly told them the worst. "The computer's insane," said Martens. "It can't even add or subtract."

"But surely we can fix it!"

Martens shook his head. He had lost all his usual cocky self-confidence; he looked, Pickett told himself, like an inflated rubber doll that had started to leak.

"Not even the builders could do that. It's a solid mass of microcircuits, packed as tightly as the human brain. The memory units are still operating, but the computing section's utterly useless. It just scrambles the figures you feed into it."

"And where does that leave us?" Pickett asked.

"It means that we're all dead," Martens answered flatly. "Without the computer, we're done for. It's impossible to calculate an orbit back to Earth. It would take an army of mathematicians weeks to work it out on paper."

"That's ridiculous! The ship's in perfect condition, we've plenty of food and fuel—and you tell me we're all going to die just because we can't do a few sums."

"A few sums!" retorted Martens, with a trace of his old spirit. "A major navigational change, like the one needed to break away from

the comet and put us on an orbit to Earth involves about a hundred thousand separate calculations. Even the computer needs several minutes for the job."

Pickett was no mathematician, but he knew enough of astronautics to understand the situation. A ship coasting through space was under the influence of many bodies. The main force controlling it was the gravity of the sun, which kept all the planets firmly chained in their orbits. But the planets themselves also tugged it this way and that, though with much feebler strength. To allow for all these conflicting tugs and pulls—above all, to take advantage of them to reach a desired goal scores of millions of miles away—was a problem of fantastic complexity. He could appreciate Martens' despair; no man could work without the tools of his trade, and no trade needed more elaborate tools than this one.

Even after the Captain's announcement, and that first emergency conference when the entire crew had gathered to discuss the situation, it had taken hours for the facts to sink home. The end was still so many months away that the mind could not grasp it; they were under sentence of death, but there was no hurry about the execution. And the view was still superb…

Beyond the glowing mists that enveloped them—and which would be their celestial monument to the end of time—they could see the great beacon of Jupiter, brighter than all the stars. Some of them might still be alive, if the others were willing to sacrifice themselves, when the ship went past the mightiest of the sun's children. Would the extra weeks of life be worth it, Pickett asked himself, to see with your own eyes the sight that Galileo had first glimpsed through his crude telescope four centuries ago—the satellites of Jupiter, shuttling back and forth like beads upon an invisible wire?

Beads *upon a* wire. With that thought, an all-but-forgotten childhood memory exploded out of his subconscious. It must have been there for days, struggling upward into the light. Now at last it had forced itself upon his waiting mind.

"No!" he cried aloud. "It's ridiculous! They'll laugh at me!"

So what? said the other half of his mind. You've nothing to lose; if it does no more, it will keep everyone busy while the food and the oxygen dwindle away. Even the faintest hope is better than none at all…

He stopped fidgeting with the recorder; the mood of maudlin self-pity was over. Releasing the elastic webbing that held him to his seat, he set off for the technical stores in search of the materials he needed.

"This," said Dr Martens three days later, "isn't my idea of a joke." He gave a contemptuous glance at the flimsy structure of wire and wood that Pickett was holding in his hand.

“I guessed you’d say that,” Pickett replied, keeping his temper under control. “But please listen to me for a minute. My grandmother was Japanese, and when I was a kid she told me a story that I’d completely forgotten about until this week. I think it may save our lives.

“Sometime after the Second World War, there was a contest between an American with an electric desk calculator and a Japanese using an abacus like this. The abacus won.”

“Then it must have been a poor desk machine, or an incompetent operator.”

“They used the best in the U.S. Army. But let’s stop arguing. Give me a test—say a couple of three-figure numbers to multiply.”

“Oh—856 times 437.”

Pickett’s fingers danced over the beads, sliding them up and down the wires with lightning speed. There were twelve wires in all, so that the abacus could handle numbers up to 999,999,999,999—or could be divided into separate sections where several independent calculations could be carried out simultaneously.

“374072,” said Pickett, after an incredibly brief interval of time. “Now see how long you take to do it, with pencil and paper.”

There was a much longer delay before Martens, who like most mathematicians was poor at arithmetic, called out “375072”. A hasty check soon confirmed that Martens had taken at least three times as long as Pickett to arrive at the wrong answer.

The atronomer’s face was a study in mingled chagrin, astonishment, and curiosity.

“Where did you learn that trick?” he asked. “I thought those things could only add and subtract.”

“Well—multiplication’s only repeated addition, isn’t it? All I did was to add 856 seven times in the unit column, three times in the tens column, and four times in the hundreds column. You do the same thing when you use pencil and paper. Of course, there are some short cuts, but if you think I’m fast, you should have seen my granduncle. He used to work in a Yokohama bank, and you couldn’t see his fingers when he was going at speed. He taught me some of the tricks, but I’ve forgotten most of them in the last twenty years. I’ve only been practising for a couple of days, so I’m still pretty slow. All the same, I hope I’ve convinced you that there’s something in my argument.”

“You certainly have: I’m quite impressed. Can you divide just as quickly?”

“Very nearly, when you’ve had enough experience.”

Martens picked up the abacus, and started flicking the beads back and forth. Then he sighed.

“Ingenious—but it doesn’t really help us. Even if it’s ten times as

fast as a man with pencil and paper—which it isn't—the computer was a million times faster."

"I've thought of that," answered Pickett, a little impatiently.

(Martens had no guts—he gave up too easily. How did he think astronomers managed a hundred years ago, before there were any computers?)

"This is what I propose—tell me if you can see any flaws in it…"

Carefully and earnestly he detailed his plan. As he did so, Martens slowly relaxed, and presently he gave the first laugh that Pickett had heard aboard *Challenger* for days.

"I want to see the skipper's face," said the astronomer, "when you tell him that we're all going back to the nursery to start playing with beads."

There was scepticism at first, but it vanished swiftly when Pickett gave a few demonstrations. To men who had grown up in a world of electronics, the fact that a simple structure of wire and beads could perform such apparent miracles was a revelation. It was also a challenge, and because their lives depended upon it, they responded eagerly.

As soon as the engineering staff had built enough smoothly operating copies of Pickett's crude prototype, the classes began. It took only a few minutes to explain the basic principles; what required time was practice—hour after hour of it, until the fingers flew automatically across the wires and flicked the beads into the right positions without any need for conscious thought. There were some members of the crew who never acquired both accuracy and speed, even after a week of constant practice: but there were others who quickly outdistanced Pickett himself.

They dreamed counters and columns, and flicked beads in their sleep. As soon as they had passed beyond the elementary stage they were divided into teams, which then competed fiercely against each other, until they had reached still higher standards of proficiency. In the end, there were men aboard *Challenger* who could multiply four-figure numbers on the abacus in fifteen seconds, and keep it up hour after hour.

Such work was purely mechanical; it required skill, but no intelligence. The really difficult job was Martens', and there was little that anyone could do to help him. He had to forget all the machine-based techniques he had taken for granted, and rearrange his calculations so that they could be carried out automatically by men who had no idea of the meaning of the figures they were manipulating. He would feed them the basic data, and then they would follow the programme he had laid down. After a few hours of patient routine work, the answer would emerge from the end of the

mathematical production line—provided that no mistakes had been made. And the way to guard against that was to have two independent teams working, cross-checking results at regular intervals.

"What we've done," said Pickett into his recorder, when at last he had time to think of the audience he had never expected to speak to again, "is to build a computer out of human beings instead of electronic circuits. It's a few thousand times slower, can't handle many digits, and gets tired easily—but it's doing the job. Not the whole job of navigating to Earth—that's far too complicated—but the simpler one of giving us an orbit that will bring us back into radio range. Once we've escaped from the electrical interference around us, we can radio our position and the big computers on Earth can tell us what to do next.

"We've already broken away from the comet and are no longer heading out of the solar system. Our new orbit checks with the calculations, to the accuracy that can be expected. We're still inside the comet's tail, but the nucleus is a million miles away and we won't see those ammonia icebergs again. They're racing on towards the stars into the freezing night between the suns, while we are coming home…

"Hello, Earth… hello, Earth! This is *Challenger* calling, *Challenger* calling. Signal back as soon as you receive us—we'd like you to check our arithmetic—before we work our fingers to the bone!"